



# Robotic End Effector for Inspection of Storage Tanks



**Developer:** Oceaneering Space Systems, Inc.  
**Contract Number:** DE-AR21-93MC30363  
**Crosscutting Area:** Robotics

**Tanks**  
**FOCUS AREA**

## Problem:

To assess the structural integrity of waste storage tanks, it is necessary to detect cracks and corrosion damage in the wall and weld joints. The tank environment precludes human inspectors, so teleoperated robots will be deployed through the tank riser access holes. It is desirable to inspect as much of a tank wall surface as possible in as little time as possible. The minimum defect of interest is a corrosion pit .125" in diameter by .125" deep.

## Solution:

Develop a robotic end effector to perform non-destructive evaluation (NDE) in conjunction with a simultaneous visual examination by the operator. The Robotic Tank Inspection End Effector (RTIEE) system combines an electromagnetic NDE technique, Alternating Current Field Measurement (ACFM), with a compact vision and lighting system to enable the operator to distinguish potential corrosion sites before approaching the tank wall for a detailed NDE. The system works

with both carbon and stainless steels.

## Benefits:

- Monitor the structural integrity of waste storage tanks using the Light Duty Utility Arm (LDUA) or other deployment system
- Single compact end-effector combines tank video and lighting with an NDE technology that can detect and size cracks and corrosion pitting in any conductive material in real time
- Advanced ACFM NDE technique has several advantages over traditional NDE techniques
- ACFM does not produce secondary waste, unlike ultrasonic NDE which requires a sound couplant material
- ACFM is a benign electromagnetic technique, unlike X-Ray which uses a hazardous source
- ACFM can detect and size defects and is much less sensitive to standoff and orientation than eddy current; ACFM works thorough most coatings including paint, epoxy, rubber, etc.



## Technology:

ACFM is an electromagnetic NDE technique that has been specifically developed to overcome the shortcomings of eddy-current techniques. ACFM combines the ability of the Alternating Current Potential Drop technique to size defects without prior calibration with the ability of eddy-current to work without electrical contact. This is achieved by inducing a uniform AC field in the target material and measuring the magnetic fields above the specimen. The uniform current flow is modeled analytically, which allows the characterization and sizing of defects without the use of artificial defect samples to calibrate the system. The use of the uniform field encourages the production of arrays of coils to cover large areas simultaneously even when relatively small defects are targets.

ACFM does not require electrical contact or a couplant interface with the tank wall surface. The RTIEE can be used to inspect large areas of a tank wall by translating, or "flying", it across the surface. The standoff distance and fly-by rate are determined by the size of the target defect. The current capability is to detect a fatigue crack while flying at 1 inch/sec. with a 1 inch standoff. On-going development efforts will

result in the same detection capability at a 2 inch/sec inspection rate. The area inspected is 6 inch wide swath.

For detailed quantified inspections, the RTIEE scanning head is positioned against the tank wall and remains stationary during the NDE. The RTIEE's scanning head is designed to self-align with the wall as the manipulator pushes the end-effector against the wall surface. All data is logged electronically and tied to the manipulator position data. A full record of current and previous inspections is kept as a "Tank Wall Map".

The scanning frame is mounted compliantly to allow the manipulator to push the scanning frame up against the tank wall to guarantee sufficiently accurate array alignment with the wall. The video camera is mounted on the centerline of the end effector, thus providing both a primary view for the operator to drive the manipulator around the tank and a direct view of the inspected area within the scanning frame. The operator is provided with both live video and the results of the ACFM inspection on the same monitor. The ACFM appraisal of the wall is presented as a two dimensional false color plot indicating defect position and size.

## Contacts:

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